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Smilovici et al.

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(54) **CUTTING INSERT HAVING CUTTING EDGES WITH RECESSED PORTIONS**

(75) Inventors: **Carol Smilovici**, Nahariya (IL); **Osama Atar**, Yarka (IL)

(73) Assignee: **Iscar, Ltd.**, Tefen (IL)

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B23C 5/20 (2006.01)

(52) **U.S. Cl.**
CPC ***B23C 5/20*** (2013.01)
USPC **407/42**; 407/61; 407/114; 407/116

(58) **Field of Classification Search**
USPC 407/42, 47, 48, 61, 113–116
IPC B23C 5/20
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,574,911	A	4/1971	Penoyar	
3,636,602	A	1/1972	Owen	
3,922,766	A	12/1975	Malinchak	
4,531,864	A *	7/1985	Bylund	407/114
4,867,616	A *	9/1989	Jakubowicz	407/58
4,936,714	A	6/1990	Demircan	
4,936,719	A	6/1990	Peters	
5,791,832	A *	8/1998	Yamayose	407/113
6,565,296	B2 *	5/2003	McKinley et al.	408/224
6,921,233	B2 *	7/2005	Duerr et al.	407/34
7,241,082	B2	7/2007	Smilovici et al.	
2010/0226726	A1	9/2010	Strasmann	

FOREIGN PATENT DOCUMENTS

DE	10 2009 002738	A1	9/2010
EP	2 106 870	A1	10/2009
GB	2054427	A *	2/1981
WO	2010/021463		2/2010
WO	WO 2010/098345	A1	9/2010

OTHER PUBLICATIONS

International Search Report dated Apr. 21, 2011 issued in corresponding International Application No. PCT/IL2010/001053.

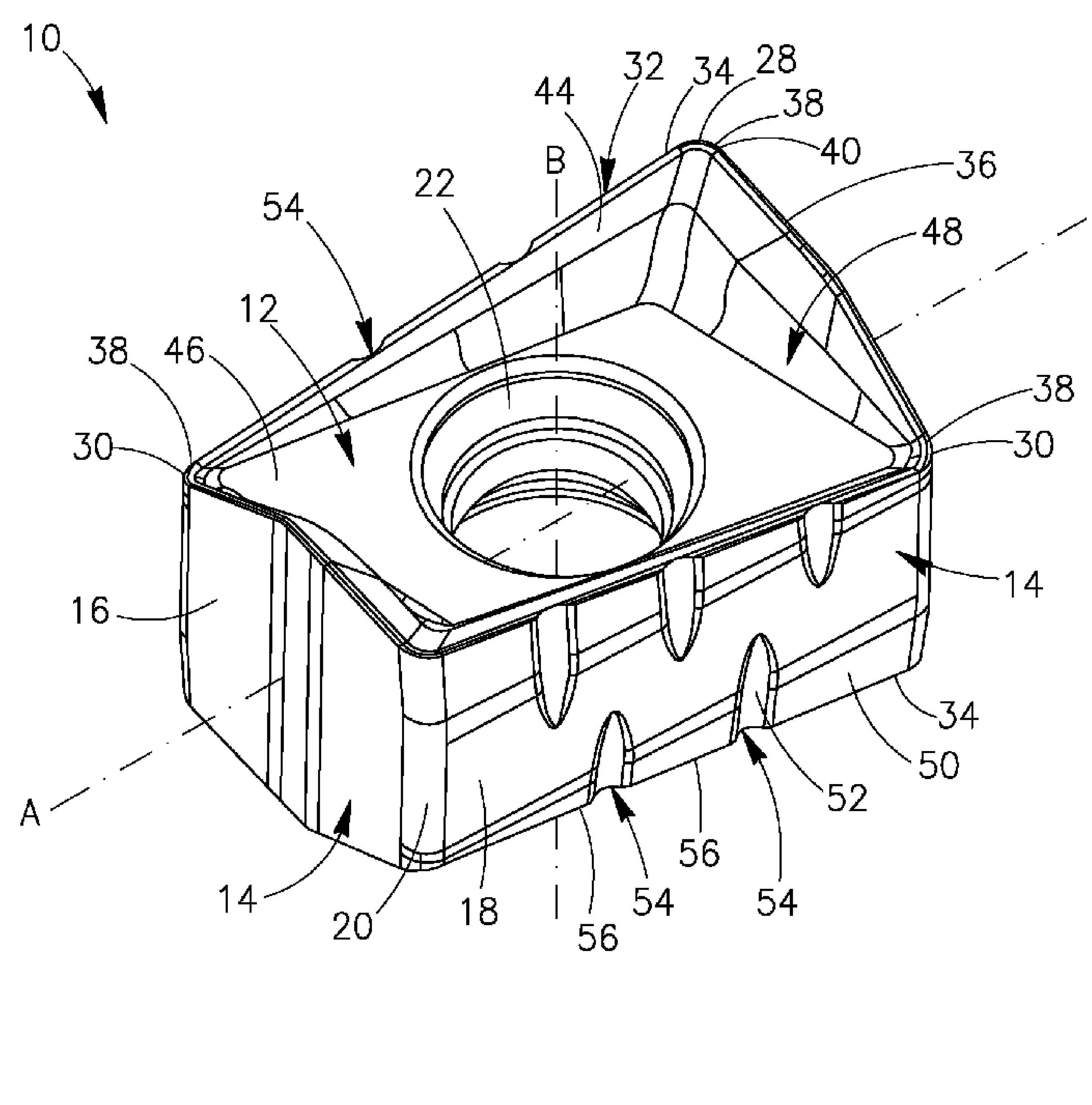
* cited by examiner

Primary Examiner — Daniel Howell
Assistant Examiner — Alan Snyder
(74) *Attorney, Agent, or Firm* — Womble Carlyle

(57) **ABSTRACT**

A cutting insert has a cutting edge formed at the intersection of a side surface an end surface. Recesses formed in the side surface interrupt the cutting edge at recessed cutting edge portions. Each recessed cutting edge portion has, in an end view of the cutting insert, a curved central section located between two curved side sections. The central section has a first radius of curvature and each side section has a second radius of curvature, the first radius of curvature being larger than the second radius of curvature.

19 Claims, 4 Drawing Sheets



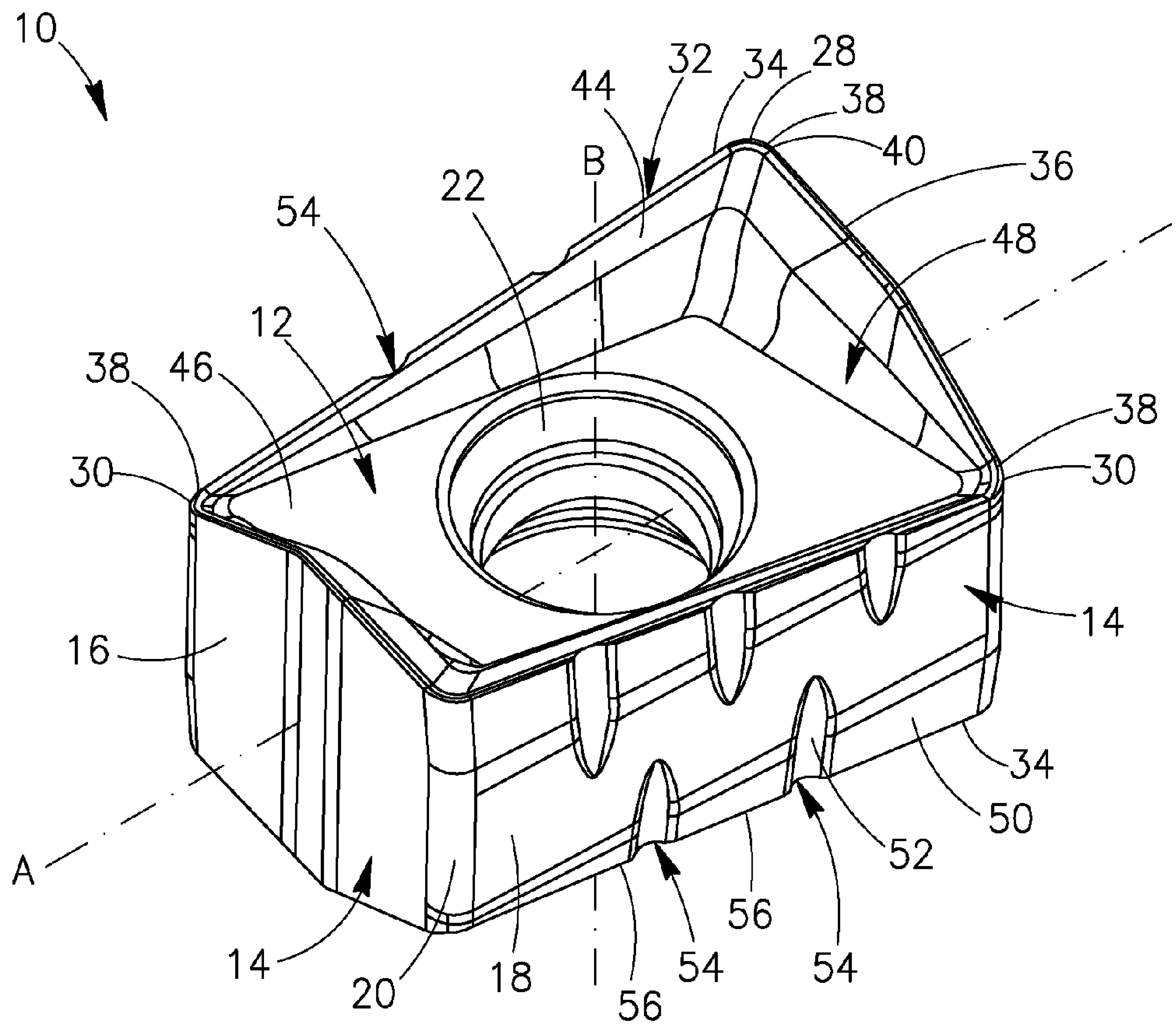

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FIG.1

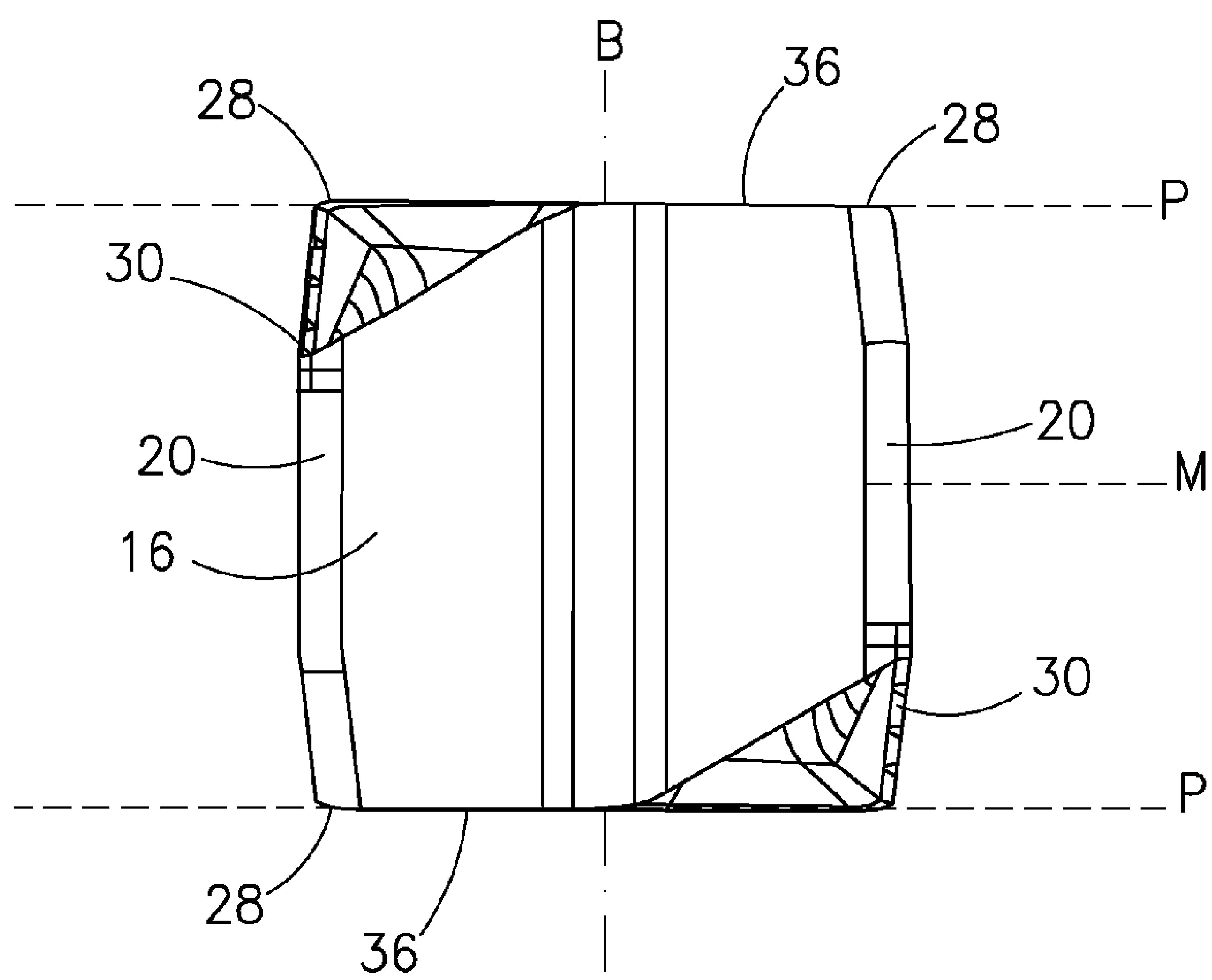
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FIG.2

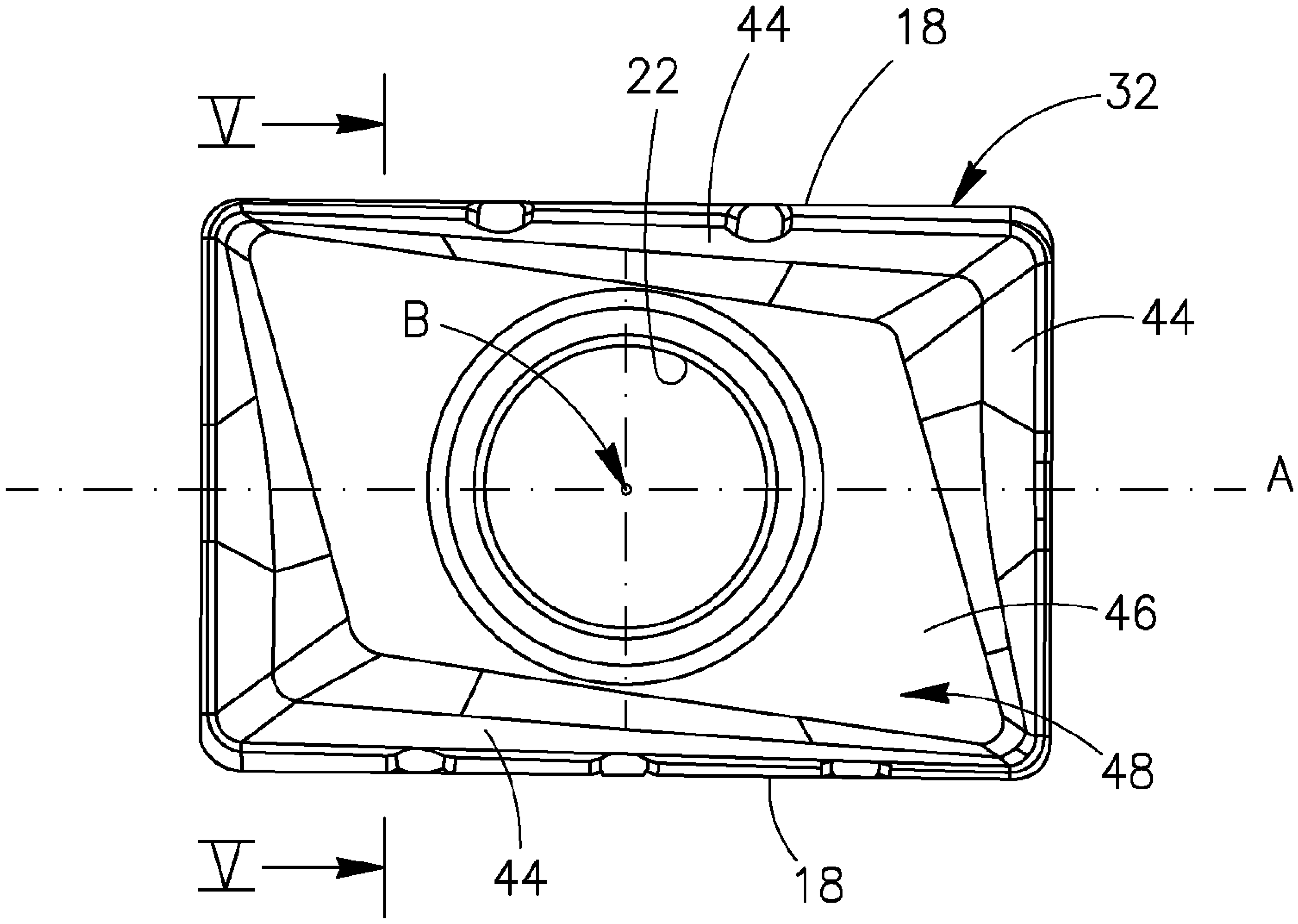

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FIG. 3

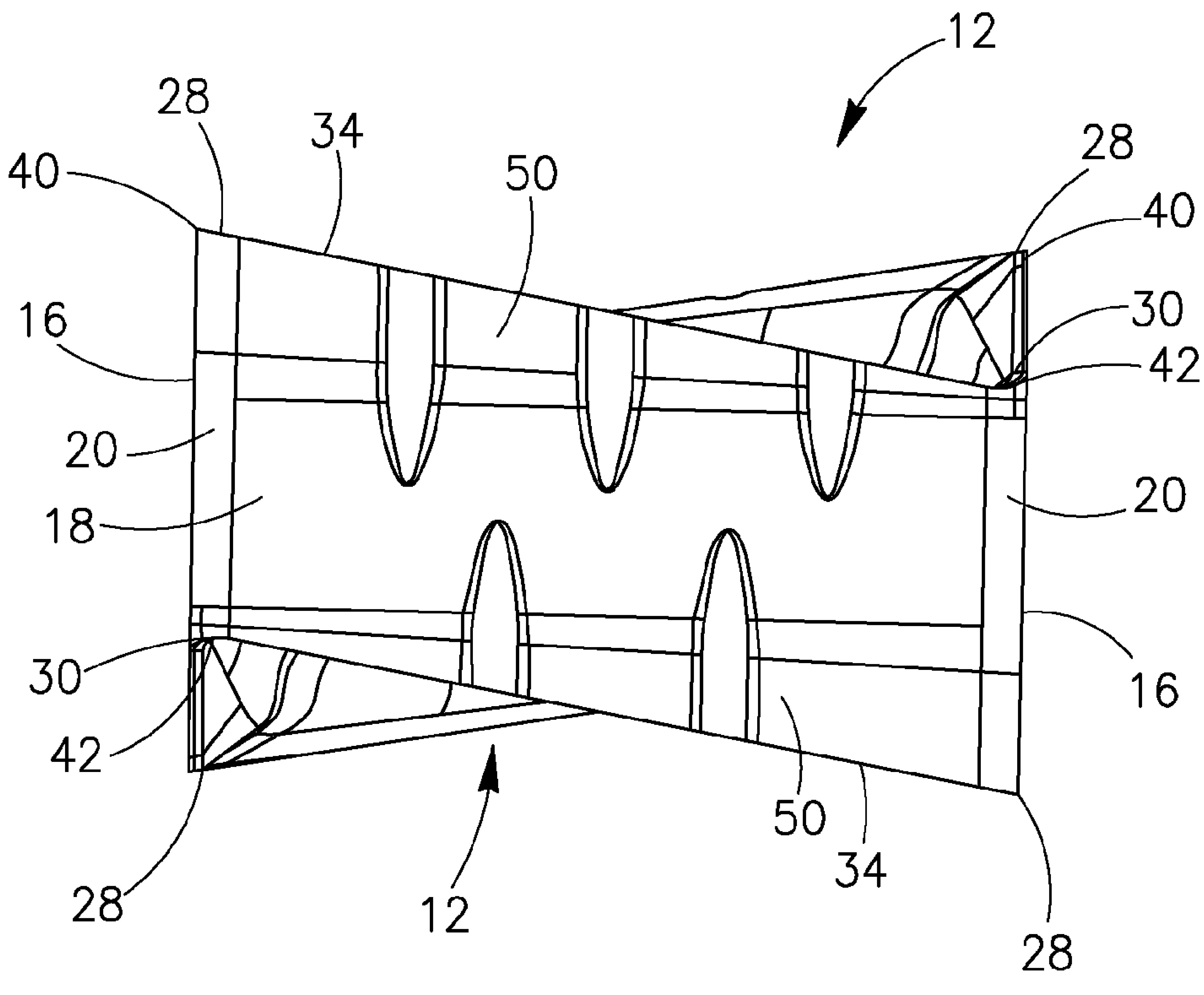

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FIG. 4

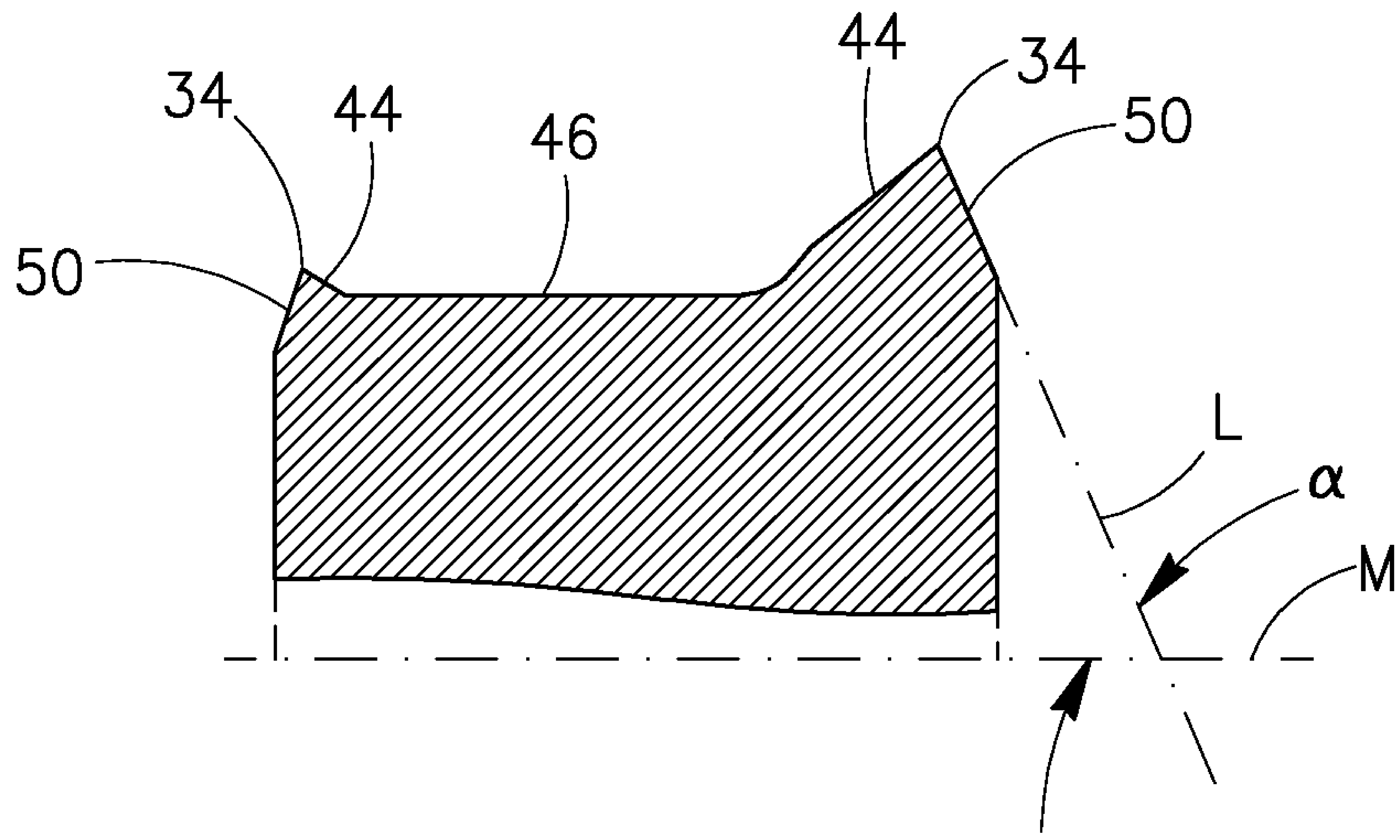

FIG. 5

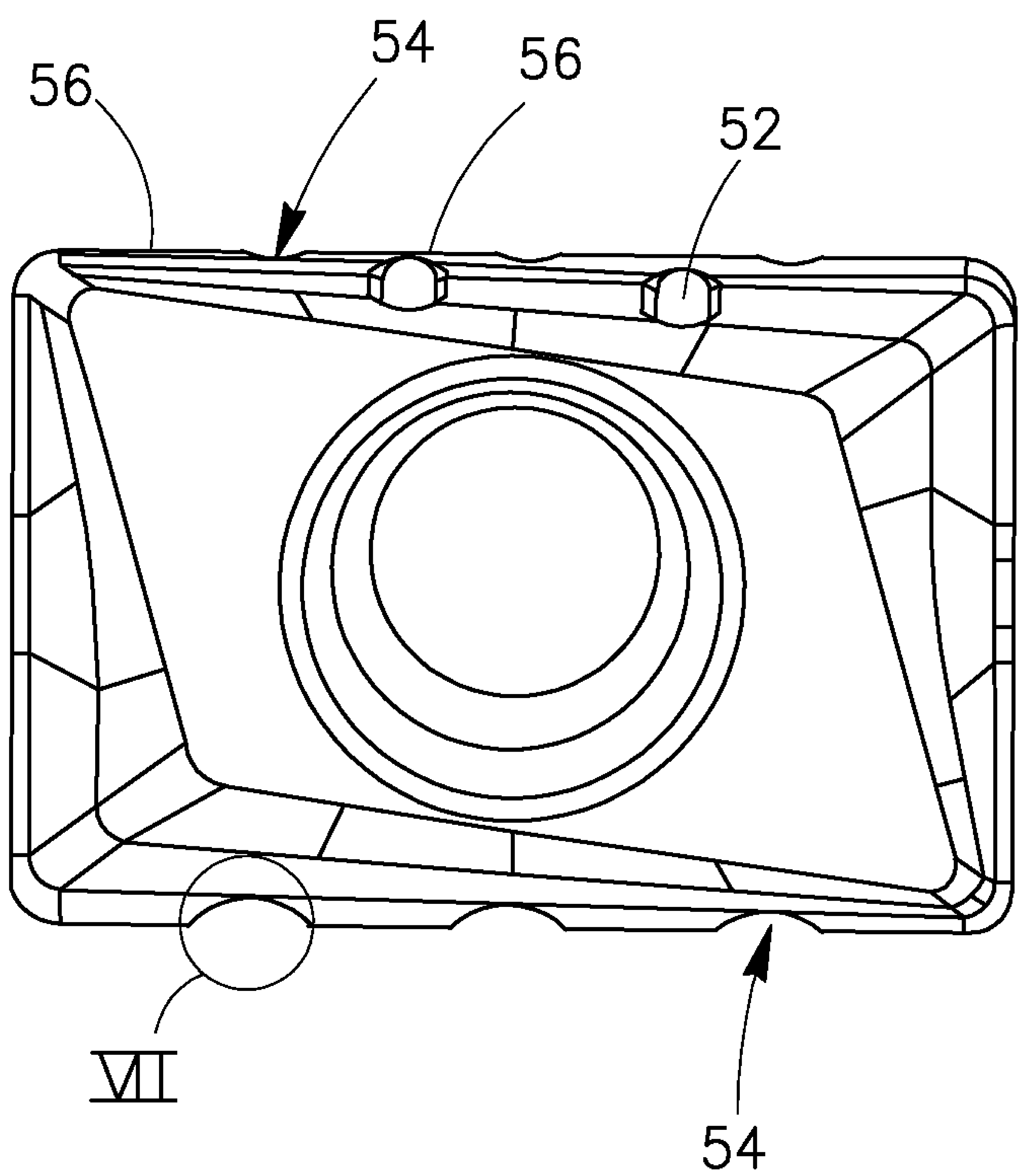

FIG. 6

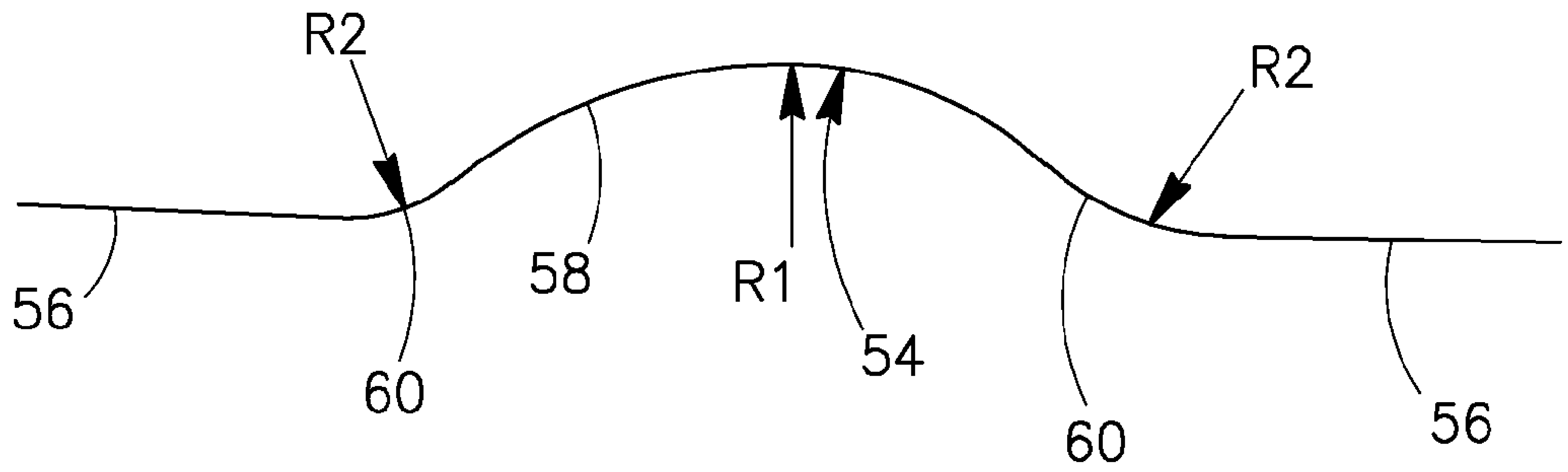

FIG. 7

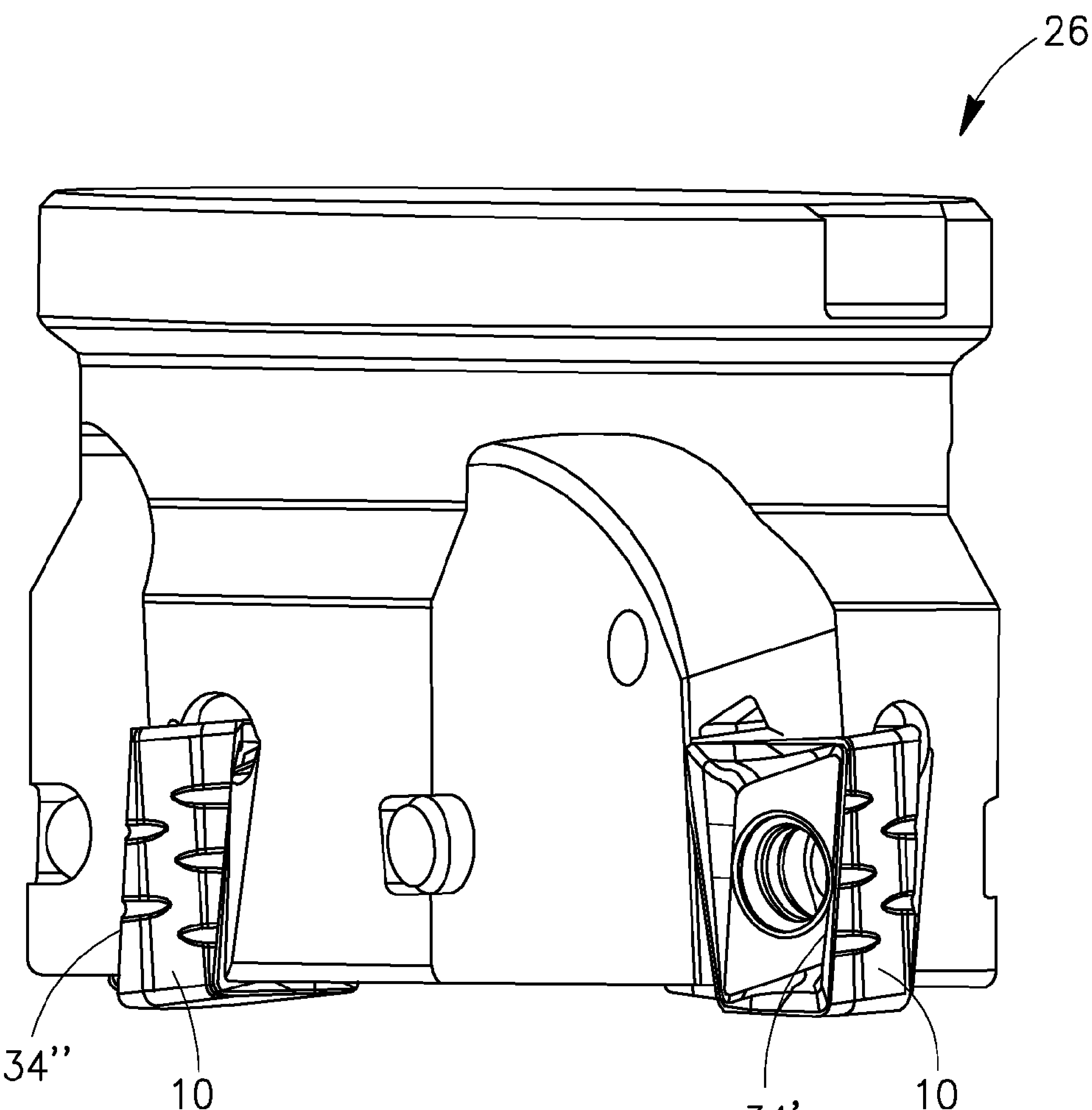

FIG. 8

CUTTING INSERT HAVING CUTTING EDGES WITH RECESSED PORTIONS

FIELD OF THE INVENTION

The present invention relates to cutting inserts having cutting edges with recessed portions.

BACKGROUND OF THE INVENTION

Cutting inserts having cutting edges with recessed portions, such as notches or grooves, are generally used for rough milling machining of metallic work pieces at high metal removal rates.

There are many examples disclosed in the art of cutting inserts having cutting edges with recessed portions. Triangular, square, round, and rectangular shaped cutting inserts are disclosed, respectively, in U.S. Pat. Nos. 3,574,911; 3,636,602; 3,922,766; and 4,936,719.

However, in such prior art cutting inserts the form of the recessed portions are generally not optimized for all-round performance and in many cases the cutting inserts are liable to break at the cutting edges during milling operations. Moreover, the general geometry of prior art cutting inserts having cutting edges with recessed portions is in many cases limited to the form of flat slabs with opposing flat parallel rake and base surfaces, or simple positive geometries, thereby limiting the range of applications of the cutting inserts.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a cutting insert comprising opposing end surfaces and a peripheral side surface extending therebetween. The peripheral side surface includes a major side surface. A major cutting edge is formed at the intersection of the major side surface with one of the end surfaces. The end surface includes a rake surface along which chips cut from a workpiece during a machining operation flow.

According to the present invention recesses formed in the major side surface interrupt the major cutting edge at recessed cutting edge portions. Each recessed cutting edge portion is located between two non-recessed cutting edge portions. In an end view of the cutting insert, when viewing the end surface with the major cutting edge, each recessed cutting edge portion comprises a curved central section located between two curved side sections.

This structure of the recessed cutting edge portions has proven to be advantageous in milling operations, especially rough milling of metallic work pieces at high metal removal rates. On the one hand the interrupted cutting edge causes chip splitting and on the other hand the curved sections provide a robust interrupted cutting edge which can withstand greater cutting forces without breaking in comparison with interrupted cutting edges in which the recessed cutting edge portions do not have this curved structure.

In accordance with a preferred embodiment, the central section has a first radius of curvature and each side section has a second radius of curvature, the first radius of curvature being larger than the second radius of curvature. This particular structure provides further strengthening of the interrupted cutting edge.

In accordance with certain specific applications optimized for best performance, the first radius of curvature is in the range 0.7 to 0.9 mm and the second radius of curvature is in the range 0.3 to 0.5 mm.

In accordance with a particular application, the first radius of curvature is equal to 0.83 mm and the second radius of curvature is equal to 0.4 mm.

The non-recessed cutting edge portions may have any one of a number of suitable geometries. In accordance with some embodiments, each non-recessed cutting edge portion may be a section of one selected from the group consisting of a straight line, an ellipse and a helix.

The present invention finds particular application with double-sided (or, double-ended) cutting inserts having "reversed-relief" primary relief surfaces. Such cutting inserts are disclosed in U.S. Pat. No. 7,241,082.

In accordance some embodiments of the present invention, the two opposing end surfaces are identical and the peripheral side surface comprises two opposing identical major side surfaces. There are four spaced apart major cutting edges. Each major cutting edge is formed at the intersection of each major side surface with each end surface. Each end surface includes associated rake surfaces. Each associated rake surface extends from a respective major cutting edge in a generally inward direction of the cutting insert to an inner end surface. Each major side surface includes associated primary relief surfaces. Each associated primary relief surface extends from a respective major cutting edge towards a middle region of the major side surface in which it is included. In each cross section of the cutting insert taken in a plane generally perpendicular to the major side surfaces, a line tangent to each primary relief surface at a non-recessed cutting edge portion of the major cutting edge is inclined to a median plane of the cutting insert at an acute interior angle (referred herein as a "reversed-relief" primary relief surface). Each end surface has four corners, two diagonally opposed lowered corners and two diagonally opposed raised corners, the lowered corners being closer to the median plane than the raised corners.

The invention is also directed to a milling cutter having at least two cutting inserts of the sort described above.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention and to show how the same may be carried out in practice, reference will now be made to the accompanying drawings, in which:

FIG. **1** is a perspective view of a cutting insert in accordance with the present invention;

FIG. **2** is a minor side view of the cutting insert in FIG. **1**;

FIG. **3** is an end view of the cutting insert shown in FIG. **1**;

FIG. **4** is a major side view of the cutting insert shown in FIG. **1**;

FIG. **5** is a partial cross section of the cutting insert shown in FIG. **1** taken along the line V-V in FIG. **3**;

FIG. **6** is an end view of the cutting insert similar to that shown in FIG. **3** but with the cutting insert rotated about the major axis A;

FIG. **7** is a detail of the cutting edge of the cutting insert shown in FIG. **6**; and

FIG. **8** is a side view of a milling cutter having cutting inserts in accordance with embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Attention is first drawn to FIGS. **1** to **7**, showing a cutting insert **10** with respect to which the present invention will be described and illustrated. However, the present invention relates to properties of the cutting edges of cutting inserts and while it is certainly applicable to the cutting insert shown in the figures, it is by no means restricted to this cutting insert which is used herein as a non-binding example. The cutting insert **10** is indexable, and is preferably manufactured by form-pressing or by injection molding and sintering carbide powders. The cutting insert **10** comprises two identical opposing end surfaces **12** of a generally rectangular shape in an end view of the cutting insert **10**.

A peripheral side surface **14** extends between the two opposing end surfaces **12** and comprises two opposed identical minor side surfaces **16**, two opposed identical major side surfaces **18** of a generally parallelogrammatic shape, and corner side surfaces **20** located between adjacent minor and major side surfaces **16**, **18**. The cutting insert **10** is provided with a through bore **22** extending between, and opening out to, the end surfaces **12**. The through bore **22** is for receiving a clamping screw to secure the cutting insert **10** to a milling cutter **26** (FIG. **8**).

Each end surface **12** has four corners, two diagonally opposed raised corners **28** and two diagonally opposed lowered corners **30**. The raised corners **28** of each end surface **12** lie in an end surface plane P. A median plane M of the cutting insert **10** is parallel to, and lies midway between, the end surface planes P. The lowered corners **30** are closer to the median plane M than the raised corners **28**. Each corner side surface **20** extends between a given raised corner **28** of one of the two opposing end surfaces **12** and a given lowered corner **30** of the other of one of the two opposing end surfaces **12**.

The cutting insert **10** has a central axis B which passes through the through bore **22** connecting the opposing end surfaces **12**. The cutting insert **10** has 180° rotational symmetry about a major axis A which passes through the two opposed identical minor side surfaces **16**, lies on the median plane M and is perpendicular to the central axis B.

A peripheral edge **32** is formed at the intersection of each end surface **12** and the peripheral side surface **14**. For each end surface **12**, the peripheral edge **32** comprises two major cutting edges **34**, formed by the intersection of the major side surfaces **18** with the end surface **12**; two minor cutting edges **36**, formed by the intersection of the minor side surfaces **16** with the end surface **12**; and four corner edges **38**, two raised corner edges **40** (each formed at a respective raised corner **28**) and two lowered corner edges **42** (each formed at a respective lowered corner **30**), formed by the intersection of the corner side surfaces **20** with the end surface **12**. The raised corner edges **40** are corner cutting edges. If desired, the lowered corner edges **42** may also be corner cutting edges. In the embodiment shown in the figures, each major cutting edge **34** extends between a given raised corner edge **40** and given lowered corner edge **42**. Similarly, each minor cutting edge **36** extends between a given raised corner edge **40** and given lowered corner edge **42**. As best seen in FIG. **2**, a first portion of each minor cutting edge **36** extends along the end surface plane P away from the given raised corner edge **40** (at a given raised corner **28**). The first portion connects to a second portion of that minor cutting edge **36** which extends away from the end surface plane P towards the given lowered corner edge **42** (at a given lowered corner **30**).

Rake surfaces **44** are formed in each end surface **12** adjacent the major and minor cutting edges **34**, **36** and the corner cutting edges **40** (**42**). The rake surfaces **44** extend from the major and minor cutting edges **34**, **36** and from the corner cutting edges **40** (**42**) in an inward direction of the cutting insert **10** to an inner end surface **46**. If desired, the inner end surface **46** of each end surface **12** is flat and the inner end surfaces **46** of each end surface **12** are parallel to each other. Preferably, in an end-view of the cutting insert **10**, the inner end surfaces **46** have the form of a distorted parallelogram (see FIG. **3**). During a metal cutting operation, chips cut from a workpiece flow from the part of the cutting edge that is in contact with the workpiece, along the rake surface **44** towards the inner end surface **46** and in some applications continue to flow along at least part of the inner end surface **46**. Therefore, the rake surface **44** and the inner end surface **46** form a chip surface **48** of the cutting insert **10**.

Each major side surface **18** comprises a primary relief surface **50** adjacent each major cutting edge **34** extending from the major cutting edge **34** towards a middle region of the major side surface **18** and towards the median plane M. In each cross section of the cutting insert **10** taken in a plane generally perpendicular to the major side surfaces **18** a line L tangent to the primary relief surface **50** at the major cutting edge **34** is inclined to the median plane M of the cutting insert **10** at an acute interior angle α (see FIG. **5**). The interior angle α may be constant or may vary continuously along the major cutting edge **34**.

Recesses **52** formed in the major side surfaces **18** interrupt the major cutting edges **34** at recessed cutting edge portions **54**. Each recessed cutting edge portion **54** is located between two non-recessed cutting edge portions **56**. As can be seen in FIGS. **3** and **6** and more clearly in the detailed view in FIG. **7**, in an end view of the cutting insert each recessed cutting edge portion **54** comprises a curved central section **58** located between two curved side sections **60**. The central section **58** has a first radius of curvature R**1** and each side section **60** has a second radius of curvature R**2**. The first radius of curvature R**1** is larger than the second radius of curvature R**2**. In some applications of the cutting insert **10** in milling machining operations, optimal performance of the cutting insert **10** was obtained with the first radius of curvature R**1** in the range 0.7 to 0.9 mm and the second radius of curvature R**2** in the range 0.3 to 0.5 mm. In a particular application, optimal performance was obtained with the first radius of curvature R**1** equal to 0.83 mm and the second radius of curvature R**2** equal to 0.40 mm.

It will be appreciated that if the recessed cutting edge portions **54** were not present, then the non-recessed cutting edge portions **56** would together comprise continuous, uninterrupted major cutting edges **34**. As is well known, in milling operations the major cutting edges **34** can have any required suitable geometry. For example, they may be straight, i.e., straight line sections, or sections of an ellipse or sections of a helix. Consequently, with the presence of the recessed cutting edge portions **54**, the non-recessed cutting edge portions **56** may also have any one of a number of suitable geometries. For example, each non-recessed cutting edge portion **56** may be a section of a straight line, an ellipse or a helix.

In accordance with a particular application, the two major cutting edges **34** associated with a given major side surface **18** have a different number of recessed cutting edge portions **54**. For example, in accordance with some embodiments one of the two major cutting edges **34** associated with a given major side surface **18** may have an even number of recessed cutting edge portions **54** and the other one of the two major cutting edges **34** associated with the given major side surface **18** may have an odd number recessed cutting edge portions **54**. In accordance with some embodiments one of the two major cutting edges **34** associated with a given end surface **12** may have an even number of recessed cutting edge portions **54** and the other one of the two major cutting edges **34** associated with the given end surface **12** may have an odd number recessed cutting edge portions **54**. Due the differing numbers of recessed cutting edge portions **54** associated with the major cutting edges **34** associated with a given end surface **12**, the cutting insert **10** does not have 180° rotational symmetry about the central axis B. Also, as seen in FIG. **4**, in a major side view of the cutting insert **10**, a maximum width among the recessed cutting edge portions **54** is less than a minimum width among the non-recessed cutting edge portions **56**.

Preferably, the recessed cutting edge portions **54** in the two major cutting edges **34** associated with the given major side surface **18** are staggered relative to each other. In accordance with a specific non-binding example shown in the figures, the number recessed cutting edge portions **54** in one of the two major cutting edges **34** mentioned above is two while the number in the other of the two major cutting edges **34** associated with the same end surface **12** is three.

Attention is now drawn to FIG. **8**, in which two cutting inserts **10** secured to the milling cutter **26** can be seen. One of the cutting inserts **10** has an operative major cutting edge **34'** with three recessed cutting edge portions **54** whereas the other cutting insert has an operative major cutting edge **34"** with two recessed cutting edge portions **54**. The recessed cutting edge portions **54** of the two operative major cutting edges **34'**, **34"** are staggered relative to each other. Since the recessed cutting edge portions **54** of the operative major cutting edges **34'**, **34"** of these two cutting inserts are staggered relative to each other, the two operative major cutting edges **34'**, **34"** complement one another to make a full cut in a work piece being milled. It has been found that it is not necessary to arrange all the cutting inserts **10** around the milling cutter in pairs having alternating operative major cutting edges **34** with staggered recessed cutting edge portions **54**. Thus, in accordance with some embodiments, only two of the cutting inserts **10** are arranged to have operative major cutting edges **34** with staggered recessed cutting edge portions **54**.

Although the present invention has been described to a certain degree of particularity, it should be understood that various alterations and modifications could be made without departing from the spirit or scope of the invention as hereinafter claimed.

What is claimed is:

1. A cutting insert comprising:

opposing end surfaces and a peripheral side surface extending therebetween, the peripheral side surface comprising a major side surface;

a major cutting edge formed at the intersection of the major side surface with one of the end surfaces; wherein:

the major side surface has recesses formed therein interrupting the major cutting edge at recessed cutting edge portions, each recessed cutting edge portion being located between two non-recessed cutting edge portions;

each recessed cutting edge portion comprising, in an end view of the cutting insert, viewing the end surface with the major cutting edge, a curved central section located between two curved side sections, the central section having a first radius of curvature and each side section having a second radius of curvature, the first radius of curvature being larger than the second radius of curvature.

2. The cutting insert according to claim **1**, wherein the first radius of curvature is in the range 0.7 to 0.9 mm and the second radius of curvature is in the range 0.3 to 0.5 mm.

3. The cutting insert according to claim **1**, wherein the first radius of curvature is equal to 0.83 mm and the second radius of curvature is equal to 0.40 mm.

4. The cutting insert according to claim **1**, wherein each non-recessed cutting edge portion is a section of one selected from the group consisting of a straight line, an ellipse and a helix.

5. The cutting insert according to claim **1**, comprising:

two identical opposing end surfaces, each end surface having four corners including two diagonally opposed lowered corners and two diagonally opposed raised corners, the lowered corners being closer to a median plane of the cutting insert than the raised corners;

two opposing major side surfaces extending between the opposing end surfaces;

four major cutting edges, each major cutting edge being formed at the intersection of each major side surface with each end surface;

a rake surface associated with each major cutting edge, each rake surface extending in a respective end surface from an associated major cutting edge in a generally inward direction of the cutting insert to an inner end surface; and

a primary relief surface associated with each major cutting edge, each primary relief surface extending from an associated major cutting edge towards a middle region of the major side surface in which it is included; wherein:

in each cross section of the cutting insert taken in a plane generally perpendicular to the major side surfaces, a line tangent to each primary relief surface at a non-recessed cutting edge portion of the major cutting edge is inclined to the median plane of the cutting insert at an acute interior angle.

6. The cutting insert according to claim **1**, wherein:

in a major side view of the cutting insert, a maximum width among the recessed cutting edge portions is less than a minimum width among the non-recessed cutting edge portions.

7. The cutting insert according to claim **1**, further comprising:

a central axis (B) which passes through a through bore passing between the opposing end surfaces; wherein:

the cutting insert does not have 180° rotational symmetry about the central axis (B).

8. A cutting insert comprising:

two identical opposing end surfaces, each end surface having four corners including two diagonally opposed lowered corners and two diagonally opposed raised corners, the lowered corners being closer to a median plane of the cutting insert than the raised corners;

a peripheral side surface extending between the two end surfaces, the peripheral side surface comprising two major side surfaces connected to two minor side surfaces;

four major cutting edges, each major cutting edge being formed at the intersection of each major side surface with each end surface; wherein:

each major side surface has recesses formed therein interrupting each major cutting edge at recessed cutting edge portions, each recessed cutting edge portion being located between two non-recessed cutting edge portions; and

each recessed cutting edge portion comprising, in an end view of the cutting insert, a curved central section located between two curved side sections, the central section having a first radius of curvature and each side section having a second radius of curvature, the first radius of curvature being larger than the second radius of curvature.

9. The cutting insert according to claim **8**, wherein the first radius of curvature is in the range 0.7 to 0.9 mm and the second radius of curvature is in the range 0.3 to 0.5 mm.

10. The cutting insert according to claim **8**, wherein the first radius of curvature is equal to 0.83 mm and the second radius of curvature is equal to 0.40 mm.

11. The cutting insert according to claim **8**, wherein each non-recessed cutting edge portion is a section of one selected from the group consisting of a straight line, an ellipse and a helix.

12. The cutting insert according to claim **8**, comprising:

a rake surface associated with each major cutting edge, each rake surface extending from an associated major cutting edge in a generally inward direction of the cutting insert to an inner end surface; and

a primary relief surface associated with each major cutting edge, each primary relief surface extending from an associated major cutting edge towards a middle region of the major side surface in which it is included; wherein:

in each cross section of the cutting insert taken in a plane generally perpendicular to the major side surfaces, a line tangent to each primary relief surface at a non-recessed cutting edge portion of the major cutting edge is inclined to the median plane of the cutting insert at an acute interior angle.

13. The cutting insert according to claim **8**, further comprising:

two opposing minor side surfaces connecting to the two opposing major side surfaces;

four minor cutting edges, each minor cutting edge being formed at the intersection of each minor side surface with each end surface; wherein:

the minor side surfaces are devoid of recesses formed therein which interrupt the minor cutting edges at recessed cutting edge portions.

14. The cutting insert according to claim **8**, wherein:

in a major side view of the cutting insert, a maximum width among the recessed cutting edge portions is less than a minimum width among the non-recessed cutting edge portions.

15. The cutting insert according to claim **8**, wherein:

the major cutting edges associated with a given end surface have a different number of recessed cutting edge portions.

16. The cutting insert according to claim **8**, further comprising:

a central axis (B) which passes through a through bore passing between the opposing end surfaces;

a major axis (A) which passes through both minor side surfaces and is perpendicular to the central axis (B), wherein:

the cutting insert has 180° rotational symmetry about the major axis (A); and

the cutting insert does not have 180° rotational symmetry about the central axis (B).

17. A milling cutter having identical first and second cutting inserts seated therein, wherein each cutting insert comprises:

two identical opposing end surfaces, each end surface having four corners including two diagonally opposed lowered corners and two diagonally opposed raised corners, the lowered corners being closer to a median plane of the cutting insert than the raised corners;

a peripheral side surface extending between the two end surfaces, the peripheral side surface comprising two major side surfaces connected to two minor side surfaces;

four major cutting edges, each major cutting edge being formed at the intersection of each major side surface with each end surface; wherein:

each major side surface has recesses formed therein interrupting each major cutting edge at recessed cutting edge portions, each recessed cutting edge portion being located between two non-recessed cutting edge portions; and

each recessed cutting edge portion comprising, in an end view of the cutting insert, a curved central section located between two curved side sections, the central section having a first radius of curvature and each side section having a second radius of curvature, the first radius of curvature being larger than the second radius of curvature.

18. The milling cutter according to claim **17**, wherein:

in each cutting insert, the major cutting edges associated with a given end surface have a different number of recessed cutting edge portions;

an operative major cutting edge of the first cutting insert has a first number of recessed cutting edge portions;

an operative major cutting edge of the second cutting insert has a second number of recessed cutting edge portions which differs from the first number;

the recessed cutting edge portions of the operative major cutting edge of the first cutting insert are staggered relative to the recessed cutting edge portions of the operative major cutting edge of the second cutting insert.

19. The milling cutter according to claim **18**, wherein each cutting insert further comprises:

two opposing minor side surfaces connecting to the two opposing major side surfaces;

four minor cutting edges, each minor cutting edge being formed at the intersection of each minor side surface with each end surface; wherein:

the minor side surfaces are devoid of recesses formed therein which interrupt the minor cutting edges at recessed cutting edge portions.

* * * * *